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2013

document version
Early version, also known as pre-print

Faculty of Economics and Business Administration

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Research Memorandum 2013-26

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Abstract

This study addresses the question whether relationships exist between innovation sources and the innovation performance of Dutch SMEs from an innovation systems and network perspective. The studies that evaluate the impact of different types of collaborative networks on innovation performance have so far shown inconsistent results. It is therefore suggested that other factors may moderate the relationship between collaborative networks and product innovation performance. Only recently, studies have attempted to examine how absorptive capacity moderates the relationship between external linkages and product innovation. The present study will add to these insights by focusing in particular on the moderating effect of absorptive capacity in SMEs. At the same time, we will investigate if the relationship between firm's capabilities to learn and innovation performance may exist through indirect causal relationships. A moderated hierarchical regression approach is used to analyse the moderating effect of absorptive capacity in SMEs. Furthermore, the mediating effect of absorptive capacity is tested by means of Structural Equation Modelling. Our results support the importance of innovation sources, in particular internal and horizontal, and absorptive capacity for succesful innovation performance of SMEs, and highlight the need for a further reconsideration of the definition of absorptive capacity for SMEs in future studies in order to unravel how learning takes place in SMEs and how it affects their innovation performance.

Key words: systems of innovation, absorptive capacity, networks, innovation performance, SMEs

6.1 Introduction

It is now widely recognized, in turbulent market economies, that innovation is the source of existence for firms, regardless of their size or other attributes. The prerequisite of every innovation is either the generation of new knowledge or, alternatively, and more typically, the combination of existing pieces of knowledge in novel, entrepreneurial ways (Schumpeter, 1934; Drucker, 1985). Innovations are to an increasing extent also seen as the result of an interactive process of knowledge generation, diffusion and application. This specifically applies to small and medium-sized enterprises (SMEs) that, due to their lack of financial and human capital resources, often do not have direct access to R&D. What is often neglected in the literature is the aspect concerning to what extent different kinds of innovation rely on specific knowledge sources and links. This possibility has been recognized only fairly recently (Tödtling et al., 2009; Freel and de Jong, 2009). This study addresses the question whether relationships exist between different information sources and the innovation performance of innovative SMEs in the Netherlands. In line with previous attempts to specify sources of information and performance (Varis and Littunen, 2010), this study approaches the issue from two different perspectives. First, the network school on innovation (e.g. Hakansson, 1987; Hakansson and Snehota, 1989), emerging from the mid-1980s onward, emphasizes the importance of external relationships, especially with other firms, in acquiring the critical inputs required to undertake innovation processes. Secondly, we draw from the system-of-innovation approach, initiated by, among others, Lundvall (1988, 1992), Freeman (1987) and Nelson (1993) that shares many common elements with the network approach, but places far more emphasis on the holistic nature of innovation, as well as on the complex web of interactions, and on the institutional environment guiding and facilitating the actions and interactions of economic agents.

The studies that did evaluate the impact of different types of collaborative networks on innovation performance (Loof and Heshmati, 2002; Criscuolo and Haskel, 2003; Miotti and Sachwald, 2003; Belderbos et al., 2004; Faems et al., 2005; Nieto and Santamaria, 2007) have so far shown inconsistent results. Tsai (2009) therefore argues that other factors may moderate the relationship between collaborative networks and product innovation performance, referring to prior research that argues that a sufficient degree of absorptive capacity is required for effective learning in a collaborative agreement between firms (Mowery et al., 1996; Lane et al., 2001). This argument is based on some important works (e.g. Cohen and Levinthal, 1990; Kim, 1997, 2001; Teece, 2000) that emphasize that a firm's absorptive capacity determines the extent to which it is able to utilize external knowledge. Only recently, studies have attempted to examine how absorptive capacity moderates the relationship between external linkages and product innovation (Tsai, 2009). The present study will add to these insights, by focusing in particular on the moderating effect of absorptive capacity in SMEs. Absorptive capacity in SMEs is considered different from absorptive capacity in larger firms, which is usually

measured as a firm's in-house R&D investment (Cohen and Levinthal, 1990; Mowery et al., 1996; Stock et al., 2001; Carayannis and Alexander, 2002; Todorova and Durisin, 2007). For a proper definition of absorptive capacity, we consider the entrepreneur as the focal level of analysis, particularly an entrepreneur's network. This study posits that SMEs' innovation performance is mediated through their ability to learn, i.e. their absorptive capacity. At the same time, we follow and elaborate on the theories of Eisenhardt, Helfat and others (Eisenhardt and Martin, 2000; Helfat et al., 2007; Zott, 2003) that the relationship between firms' capabilities to learn and innovation performance may exist through indirect causal relationships.

The sample used in this research is drawn from a survey among Dutch SMEs that participated in a government subsidy programme which was aimed to improve knowledge relations between universities and other knowledge institutions and SMEs. In the period 2006-2009 the SMEs that were questioned successfully applied for the subsidy which consisted of a sum of money of € 2,500 or 7,500 euro that went by the name of 'small' or 'large' innovation voucher respectively. Because of communication problems or time limitations, however, not all SMEs actually used the subsidy. For this study, we only regarded the survey results of SMEs that used their voucher. The sample is thus unique because it is comprised of those companies that see value in innovation and in government programmes of this kind. A moderated hierarchical regression approach is used to analyse the moderating effect of absorptive capacity. Furthermore, the mediating effect of absorptive capacity is tested through the use of Structural Equation Modelling (SEM). The study is structured as follows: Section 2 reviews the literature and provides theoretical expectations. Section 3 introduces the research methods, including the models, variable definitions and measurements, and the sample used in this study. Section 4 presents and discusses the results. Section 5 summarizes the results, discusses the implications for theory and managerial practice, and suggests possible directions for future research.

6.2 Literature review and research hypotheses

6.2.1 Literature on innovation systems and knowledge networks

The suggestion that innovation is an interactive process is nowadays broadly accepted (Tödtling et al., 2009). However, different interactive approaches consider different actors, key factors and relations to be central for innovation. In particular, the innovation system concepts (Lundvall, 1992; Nelson, 1993; Edquist, 1997, 2005; Breschi and Malerba, 1997; Cooke et al., 2000; Cooke et al., 2004; Doloreux, 2002; Asheim and Gertler, 2005) and the innovation networks and related works (De Bresson and Amesse, 1991; Cooke and Morgan, 1998; Powell, 1998; Hagedoorn, 2002; Fritsch, 2003; Powell and

Grodal, 2005; Giuliani, 2007; Nieto and Santamaria, 2007) are highlighted in this respect, because they are generally more explicit in terms of the kinds of knowledge sources and the types of interactions and links involved in the innovation process. The innovation system literature argues that the institutions relevant for a specific sector (SIS), a country (NIS), or a region (RIS) have an influence on innovation. Of key importance are the regulatory context (such as intellectual property rights, technical standards), organizations for knowledge generation and diffusion (universities, education, technology transfer), and firms willing and capable to commercialize such knowledge. The network approach looks at specific, well-selected relationships in the innovation process among specific actors both in the region and beyond. It stresses motives for engaging in cooperation such as technological complementarities or access to resources and specific knowledge, and it emphasizes the role of trust and social capital for the development of networks.

The literature describes a large variety of knowledge links, but overall there is still little clarity on the types of knowledge relations involved. In this respect, Tödtling et al. (2009) distinguish between traded (formal) and untraded (informal) relationships (based on Storper, 1997), and between static and dynamic knowledge interactions (based on Capello, 1999). With regard to the first set of relationships, in particular the untraded, often informal relations might explain the spatial concentration of innovative industries and activities rather than the traded more formalized interactions among firms. Regarding the second dimension, static knowledge exchange implies a transfer of 'ready' pieces of information or knowledge from one actor to another, such as the licensing of a specific technology or the interpretation of a patent description. Dynamic knowledge exchange refers to a situation where interactive learning takes place among actors through cooperation or other joint activities, as described by Camagni (1991) and Lawson (2000). For the definition of our research model, we take this view on types of knowledge interactions in the innovation process as the starting point. In their article, Tödtling et al. (2009) refer to their four main types of relations as 'ideal types' which in reality can be rarely observed in pure form (see Figure 1). We believe, however, that by analysing knowledge relations and networks of Dutch SMEs in this form that we can make the classification more concrete and provide more accurate information on the types of knowledge relations involved and their role in the innovation process of SMEs.

	Static (knowledge transfer)	**Dynamic (collective learning)**
Formal/ traded relation	Market relations	Cooperation/ formal networks
Informal/ untraded relation	Knowledge externalities and spillovers	Milieu/ Informal networks

Figure 1 Types of knowledge interactions in the innovation process (Tödtling et al., 2009).

6.2.2 Hypotheses: knowledge transfer through sources of information

Market relations

Tödtling et al. (2009) refer in the case of market relations to the buying of technology and knowledge in various forms such as the buying of machinery, ICT equipment or software, or the buying of licences. The relation or knowledge transfer is static because the technology or knowledge is traded more or less in ready form. In this study, however, SMEs are central and their financial resources are often limited. As the firms' ability to attract and maintain a highly qualified labour force is important (Bougrain and Haudeville, 2002), with regard to SMEs, more important than attracting pure R&D may therefore be the existence of a skilled and technically qualified workforce. Further, as already indicated, firms, especially smaller ones, generally cannot rely solely on their internal knowledge and competences in their innovation process but are forced to seek complementary information from their environment. With regards to market relations, previous research has particularly emphasized the importance of vertical relationships with suppliers and customers as an important source of innovation-related inputs (von Hippel, 1988; Lundvall, 1992), but sometimes horizontal relationships with competitors are also of importance (Hamel et al., 1989). Our first set of hypotheses are therefore formulated as follows:

H1: Internal sources of innovation are positively associated with SMEs' innovation performance

H2: Vertical sources of innovation are positively associated with SMEs' innovation performance

H3: Horizontal sources of innovation are positively associated with SMEs' innovation performance

Knowledge externalities and spillovers

While the network approach to innovation mainly emphasizes the relationship between business firms, the systems-of-innovation approach takes a broader perspective, and attempts to capture all the important factors that influence the generation, utilization, and diffusion of economically useful knowledge (Lundvall, 1992; Edquist, 1997). Within the systems-of-innovation approach, the creation, selection and transformation of knowledge takes place within a complex matrix of interactions between different actors (firms, universities and other research organizations, educational organizations, financial organizations, public support organizations, etc.), and within a diverse economic, institutional, social, political, cultural, and geographical context. Tödtling et al. (2009) particularly highlight local knowledge externalities or spillovers from universities and research organizations to firms, whereby they argue that, different from market links, in these cases there is often no contract or formal compensation for the

acquired knowledge. Local knowledge spillovers are further regarded by the literature to particularly result from various kinds of mechanism such as patents, and knowledge exchange through mobile labour, or through informal contacts (Feldman, 2000). In addition, there are many other informal sources of information that firms may screen for ideas for innovation, many of which are generally accessible to anyone. Some typical examples are the Internet and other media, commercial exhibitions and fairs, scientific and professional literature, trade journals, educational events, and so forth (Varis and Littunen, 2010). On the basis of the existing knowledge relations and spillovers literature, we have formulated the following five hypotheses:

H4: Public sources of innovation are positively associated with SMEs' innovation performance

H5: Financial sources of innovation are positively associated with SMEs' innovation performance

H6: Educational sources of innovation are positively associated with SMEs' innovation performance

H7: Research sources of innovation are positively associated with SMEs' innovation performance

H8: Informal sources of innovation are positively associated with SMEs' innovation performance

6.2.3 Hypotheses: collective learning through absorptive capacity

In the innovation literature, the dynamic aspect of collective enhancement of the local knowledge base through collective learning is generally linked to absorptive capacity (Cohen and Levinthal, 1990, for empirical evidence see also: Caloghirou et al., 2004; Cassiman and Veugelers, 2006; Nieto and Quevedo, 2005; Santamaria et al., 2009; Vega-Jurado et al., 2008; Veugelers, 1997). More specifically, absorptive capacity means that a firm must possess adequate internal knowledge and capabilities, often but not necessarily always attained through in-house R&D, in order to get access to, and gain from, externally generated knowledge. Increasingly, the idea exists in the literature that, when assessing the innovation potential of a firm, the importance of firm's internal R&D intensity may be easily overestimated. Although carrying out in-house R&D is important to strengthen the firm's innovation performance (Cohen and Levinthal, 1990), R&D is by no means the guarantee or the imperative of success. Background to this reconsideration of in-house R&D is the growing attention for small firms and their role innovation process in the literature (see, for example, Alvarez and Busenitz, 2001). Traditionally the organization-level analysis of innovation-related activities and resources has been conducted in large

firms. However, analysis of SMEs' innovation-related activities and resources requires a different approach. Actions made by a firm are generally considered a source of sustainable competitive advantage. Increasingly, these actions are linked to the behaviour of entrepreneurs, i.e. an entrepreneur's human capital resources as well as firm resources relating to tacit knowledge, technological resources (i.e., imagination, creativity, innovativeness, etc.), finance, reputation and goodwill, organizational routines and skills (Penrose, 1959). The notion of absorptive capacity then, is what firmly connects the innovative firm with its surrounding environment. For resource-poor SMEs, this will most likely be their network. Similar to Tödtling et al. (2009), who refer to dynamic learning as the more durable and interactive relations between specific partners in the innovation process (i.e. networks), we therefore regard the absorptive capacity of SMEs to exist mainly in the form of networking skills of SMEs. This study argues that particularly the intensity of the network as well as contacts with international networks affect SMEs' relationship between sources of innovation and competitive advantage. In many SMEs, the owner is the key resource. Particularly during the early stages of private firm development, owner(s), not organization, characteristics play a pivotal role in shaping performance (Kunda and Katz, 2003). So, an entrepreneur's resource profile can shape firm performance. Previous experiences (Reuber and Fischer, 1997), resources (Bloodgood et al., 1996), capabilities, knowledge and learning mobilized by an entrepreneur (or entrepreneurial team) may lead to the creation, discovery, and exploitation of opportunities in domestic and foreign markets. Therefore, we believe that network intensity should be regarded a blueprint of an entrepreneur's previous experiences, capabilities, knowledge and learning. Further, the entrepreneur's expertise and cognitive processes are highly influential in international opportunity exploitation (Jones and Coviello, 2005). Thus, we argue that contacts with an international network should also be considered as a proxy for absorptive capacity in SMEs, more so than in-house R&D. Our second set of hypotheses are therefore formulated as follows:

H9: The greater the absorptive capacity, the stronger the relationship between contact with sources of innovation and SMEs' innovation performance

H10: SMEs' innovation performance is likely to be positively influenced by their absorptive capacity

H11: SMEs that use sources of innovation are likely to have increased innovation performance only through their absorptive capacity.

6.3 Research method

6.3.1 Conceptual framework

Figure 2 shows the conceptual framework of knowledge interaction in the innovation process of SMEs that will be investigated in this study. We base this on the framework used by Tsai (2009) and Liao and Rice (2010), and aim to look particularly at SMEs. Further, on the basis of the classifications of Tödtling et al. (2009), we discern a more static knowledge transfer phase, as well as a more dynamic phase of collective learning. Both phases have an effect on the SMEs' innovation performance, but in the second dynamic phase we predict that the learning effect is moderating rather than direct. Next, the possibility of a mediating effect of absorptive capacity between sources of innovation and innovation performance will be tested through Hypotheses 10 and 11. Further, we assume that location of the firm, age of the owner/manager, firm existence, and education of the owner/manager may influence the relationship between knowledge transfer and innovation performance, and they are therefore included as control variables in the model to eliminate or reduce the bias arising from these effects.

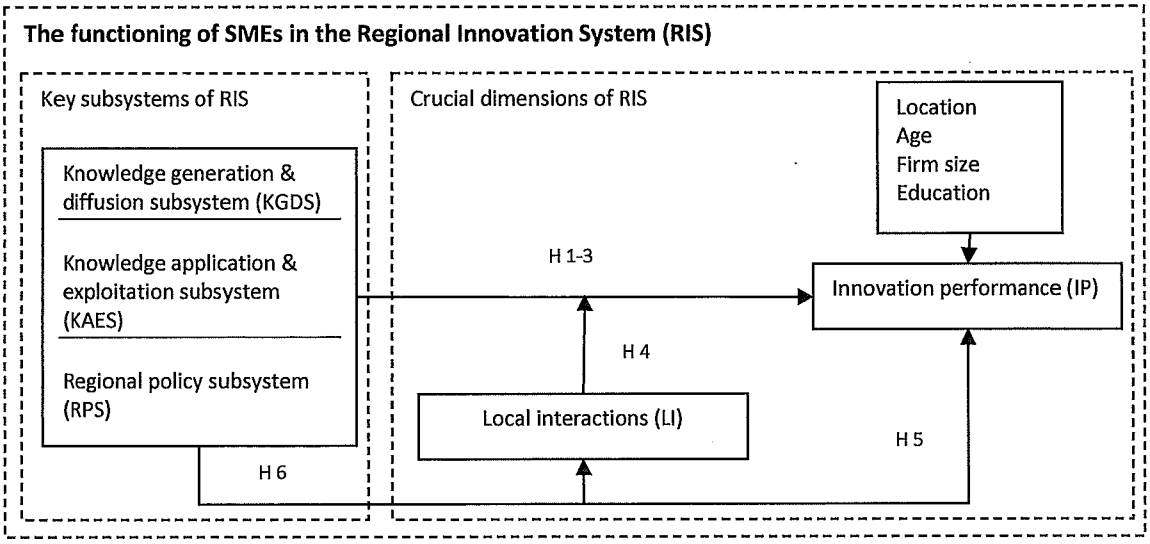

Figure 2 Conceptual model based on the systems of innovation and innovation networks approaches

6.3.2 Variable definitions

Dependent and independent variables

The dependent variable in this study is innovation performance, which is a sum-variable consisting of variables that measure the development of new products, services or processes and the improvement of existing products, services or processes, as well as the SMEs' percentage increase in sales in 2009 from new or improved products, services or processes (see Table 2 for further details). A

technologically new product is a product whose technological characteristics or intended uses differ significantly from those of existing products (OECD, 1997). A technologically-improved product refers to an existing product whose performance has been significantly improved or upgraded (OECD, 1997). Further, the OSLO Manual (OECD, 1997) proposes that innovation performance can best be measured by the proportion of sales as a result of technologically new or improved products. This indicator has been widely adopted in innovation studies (Evangelista et al., 2001). The independent variables in this study are the eight types of innovation sources discussed in the literature review, i.e. public, vertical, internal, horizontal, financial, educational, research, and informal sources of innovation. Besides horizontal sources of innovation, the variables are sum-variables consisting of two or more variables that measure specific sources that SMEs may normally use for innovation. Individually, they are all dummy variables which take the value of 2 if the SME uses the source for knowledge for innovation, or otherwise 1.

Table 2 Description of the variables used in this study

Variable	Description	Scale of measurement
Dependent variables		
Innovation performance	Sum-variable measuring the innovation and sales performance of SMEs:	
	Radical innovation	
	Mean-variable consisting of:	
	Development of new products or services	1= no 2= don't know/ no answer 3= yes
	Development of new production or service processes	1= no 2= don't know/ no answer 3= yes
	Incremental innovation	
	Mean-variable consisting of:	
	Improvement of existing products or services	1= no 2= don't know/ no answer 3= yes
	Improvement of existing production or service processes	1= no 2= don't know/ no answer 3= yes
	Sales performance	
	Percentage increase in sales in 2009 from new or improved products/ services/ processes from the period 1 January 2006 until 1 January 2010	1= decrease 2= none 3= don't know/ no answer 4= very low percentage 5= low percentage 6= average 7= high percentage 8= very high percentage
Independent variables		
Knowledge generation & diffusion subsystem (KGDS)	Mean-variable measuring use of knowledge infrastructure that SMEs normally use for innovation:	
	University	1= no 2= yes
	University of professional education	1= no 2= yes

	College for secondary vocational training	1= no 2= yes
	Research institutions (TNO, EIM, etc.)	1= no 2= yes
Knowledge application & exploitation subsystem (KAES)	Mean-variable measuring use of firm or business dimensions of SMEs:	
	Customers	1= no 2= yes
	Suppliers	1= no 2= yes
	Employees	1= no 2= yes
	Concern or umbrella company	1= no 2= yes
	Other firms/ competitors	1= no 2= yes
Regional policy subsystem (RPS)	Sum-variable measuring the policy dimensions of a RIS for SMEs:	
	Government (for example Agentschap.nl or Syntens)	1= no 2= yes
	Trade organisations	1= no 2= yes
	Chamber of Commerce	1= no 2= yes
	Financial institutions (banks, etc.)	1= no 2= yes
	Audit firms	1= no 2= yes
Local interactions (LI)	Interaction-variable measuring the extent of local interactions of firms:	
	Extent to which employees (including owner/ manager of SME) have contact with professional networks	1= not 2= don't know/ no answer 3= irregular 4= yearly 5= monthly 6= weekly 7= daily
	Contact with international networks	1= no 2= yes
Control variables		
	Location	1= outside university city 2= inside university city
	Age	1= 20-29 2= 30-39 3= 40-49 4= 50-59 5= 60-69 6= 70-79 7= >79
	Firm size	1= 1-9 (micro) 2= 10-49 (small) 3= 50-250 (medium)
	Education	1= primary school 2= lower vocational training 3= MAVO/MULO/VMBO 4= vocational training

	5= HAVO/VWO/HBS 6= university of professional education 7= university 8= PhD

Moderator/mediator and controls

The moderating variable is local interactions. Firms can only be expected to learn from their collaborators if they have some level of prior (technological) knowledge that they can use to incorporate with their partners' knowledge and use it for their own purposes. The absorptive capacity of a firm is thus a result of the human capital already embodied in the owner of the firm and its workers. Taking into account the reputation of influential entrepreneurs like Steve Jobs and Bill Gates, this study argues that an entrepreneur's network skills are a better proxy for prior knowledge and the capability level of the firm than schooling/training of the entrepreneur and its workers (if any). Prior research reviews in-house R&D investment as the key determinant of a firm's absorptive capacity (Cohen and Levinthal, 1990; Mowery et al., 1996; Stock et al., 2001; Carayannis and Alexander, 2002; Todorova and Durisin, 2007). More recently, Tsai (2009) sucessfully added training of the workforce as a proxy for larger firms. However, for samples consisting primarily of smaller firms such proxies fail to capture the learning process. Therefore, in this study, the absorptive capacity variable is measured by dividing an SME's network intensity, i.e. the extent to which employees (including the owner/manager of the SME) have contact with professional networks, and SME's contact with international networks divided by its firm size.

Also, several control variables are used in the model. The first control is the use of the dummy location to test for proximity effects, whereby location in a university city takes the value of 2, or otherwise 1. A number of studies have demonstrated through econometric methods that there are considerable local knowledge externalities or spillovers, in particular from universities and research organizations to firms (for example, the studies applying the knowledge production function approach, e.g. Audretsch and Feldman, 1996; Anselin et al., 1997; Bottazi and Peri, 2003). Age and firm existence are used as controls to test for the effects of experience. Previous experience determines the routines, which are fundamental to the firm's future actions, and these routines have to be relevant to those needed in a particular market (Madhok, 1997). Given a wide choice of alternative ideas, SMEs with increasing invention experience are more likely to select the ideas of others from a comparison group that is at the frontier of knowledge and solution development (Lewin and Massini, 2004). The age of the owner/manager and years of firm existence may therefore be considered to affect the model. Finally, the education level of the owner/ manager of the SMEs serves as a proxy for the quality of the firm's human resources, which is an important determinant of innovation output in the literature (Rothwell and

Dodgson, 1991; Jones, 2001). Higher educated entrepreneurs may be more likely to stimulate learning in their organization.

6.3.3 Data description

Our sample consists of 416 Dutch SMEs that have participated in a subsidy scheme of the Ministry of Economic Affairs that goes by the name of the 'innovation vouchers programme'. In 2006, the government of the Netherlands officially launched this subsidy programme that aimed to promote knowledge transfer to SMEs by means of 'Innovation Vouchers' in order to encourage the flow of information from knowledge institutes (KIs) to SMEs. Our database consists of SMEs that applied for a small or large innovation voucher in the period 2006-2008, hence after the programme was officially launched. An innovation voucher is 'a (relatively small) sum of money made available by the Dutch government, with the particular aim to improve access for SMEs to the knowledge available within (public) KIs. Per year about 3000 small vouchers and 3000 large vouchers were made available by the Dutch government. The database is considered particularly valuable because it consists of SMEs that have the intention to be innovative, and aim to improve contacts with one or more KIs. In this study, the focus is on innovative SMEs that demonstrate 'active strategic commitment to research and technological change' (Motwani et al., 1999), and exploit external opportunities for inward investment and information gathering (Heunks, 1998). In this survey, a majority of firms are micro-sized, with 1-9 employees (60 per cent). More importantly, of the 416 respondents that replied to our questionnaire, a majority (68.9 per cent) indicated to have had previous contacts with the KI of their choice, because the vouchers were easily accessible. There was no assessment upfront for SMEs. The sample is thus not representative for SMEs in the Netherlands generally, because it is comprised of those companies that, often, already have innovation contacts with KIs and see value in government programmes of this kind.

Quantitative data was collected by means of a survey which was both made available online and sent as a paper version to 2253 SMEs in July 2010. General aim of the survey was to research the innovation sources and networks of Dutch SMEs and study their influence on the performance of these firms. The questionnaire design was partly based on the Dialogic (2008) evaluation in order to allow for comparison. Test questionnaires were sent colleagues and SMEs in June, and on the basis of their comments the questionnaire was further improved. Address details were made available by Agentschap.NL, which is a division of the Dutch Ministry of Economic Affairs that is in charge of the innovation voucher programme. The majority of respondents returned the questionnaire by mail. A stamped-addressed return envelope was sent along with it to increase the response rate. Also, per valid questionnaire, €1 was donated to a good cause (Cordaid Micro Credit). It turned out that the paper version was preferred because it gave the respondents more freedom to add a comment, remark, or

clarification. In total 416 valid questionnaires were returned by January 2011. The response rate of 18.5 per cent is comparable with the general response rate from questionnaires, which is between 5 and 15 per cent (Miles and Huberman, 1999). All questionnaires were manually entered into an SPSS-database. Further, as this study focuses on innovative SMEs, SMEs that applied for a small or large voucher, but did not use the voucher, because of, for example, time limitations (a voucher is valid for 1 year only), were deleted from the sample.

Table 3 reports the basic statistics for the variables used in the analysis. Based on the correlation coefficients for the SI variables that achieve a statistical significance at the 5 per cent significance level, a certain proportion of the firms within the sample use more than one source of innovation. In particular, SMEs that use vertical sources of innovation tend to also use internal sources of innovation (r=0.255, p<0.01), horizontal sources of innovation (r=0.278, p<0.01), and informal sources of innovation (r=0.191, p<0.01), which indicates the existence of strong market relationships between SMEs. At the same time, SMEs collaborating with public sources of innovation tend to also have strong links with educational sources of innovation (r=0.174, p<0.01), financial sources of innovation (r=0.218, p<0.01) and informal sources of information (r=0.151, p<0.01), besides the more market-oriented vertical (r=0.175, p<0.01) sources of innovation. There is no significant correlation of the control variables with SMEs' innovation performance, which suggests that the control variables do not affect our model.

Table 3 Mean, standard deviations, and correlations (N=320)

Variable	1	2	3	4	5	6	7	8	9
1. IP	1.000								
2. KGDS	0.093[c]	1.000							
3. KAES	0.257[a]	0.088[a]	1.000						
4. RPS	0.094[c]	0.110[b]	0.192[a]	1.000					
5. LI	0.254[a]	0.192[c]	0.131[b]	0.018	1.000				
6. Location	0.082	-0.014	0.078	-0.084	0.017	1.000			
7. Age	0.026	0.048	0.006	0.046	0.135[b]	0.004	1.000		
8. Firm size	0.015	0.008	0.009	0.022	0.044	-0.031	-0.084	1.000	
9. Education	0.080	0.028	0.069	0.048	0.054	0.180[a]	0.016	0.033	1.000
Mean	12.934	1.173	1.361	1.145	6.386	0.284	3.313	1.541	5.978
S.D.	2.780	0.360	0.241	0.181	3.551	0.452	1.084	0.725	1.154

Note: [a] p<0.01; [b] p<0.05; [c] p<0.10.

6.4 Analysis

6.4.1 Results: ACAP as moderator between IS and IP

The model in this study is estimated by OLS-based hierarchical regression. In Table 4 the results of the hierarchical regression analysis are shown for IP. Model 1 contains the control variables location, age, firm existence, and education. In Model 2, absorptive capacity (ACAP) and the knowledge network

variables (SI – public, SI – vertical, SI – internal, SI – horizontal, SI – financial, SI – education, SI – research, and SI - informal) are entered into the model. In the survey, respondents were asked what sources of innovation they would normally use. For exploratory reasons, we have added all innovation sources that are listed in the survey into the analysis. We are aware that this may lower the explanatory power of the models. The terms of interaction between the sources of innovation variables and the ACAP variable are added in Model 3. Because the interaction terms are usually highly correlated with ACAP or the knowledge exchange variables, this study follows the procedure suggested by Friedrich (1982) to reduce or eliminate any contamination of the results due to multi-collinearity. This approach first standardizes the variables, and then forms the cross-product terms. Table 4 indicates that adding the knowledge exchange and ACAP variables (Model 2) to the model with only the controls (Model 1) increases the R^2 by about 13 per cent. The *F*-value (5.25) for the incremental R^2 achieves a statistical significance at the 1 per cent level. An inspection of the coefficient estimates of the sources of innovation variables shows that these variables explain the change in innovation performance for internal and horizontal sources of innovation. This result implies that the knowledge of employees and umbrella companies (internal sources of innovation), as well as knowledge of competitors (horizontal sources of innovation), increases the innovation performance of innovative SMEs when the analysis does not account for the effect of ACAP. The mere existence of internal sources of innovation can in this respect be regarded as an advantage of larger SMEs over smaller ones. The significance of horizontal sources of innovation is, however, less often associated with innovation performance. Malmberg and Maskell (2002) are among the few who mention the importance of competitors (i.e. for monitoring and imitation) in relation to innovation and knowledge interaction. Adding the interaction terms (Model 3) to Model 2 further increases the R^2 by about 3 per cent. The *F*-value (1.18) for the incremental R^2 value fails, however, to achieve statistical significance, which indicates that the interaction terms of both the sources of innovation variables and the ACAP variable do not have explanatory powers with regard to the change in the SMEs' innovation performance. There is thus not a significantly strong interaction effect between absorptive capacity and sources of innovation on innovation performance, which may indicate that ACAP does not moderate the relationship between sources of innovation and innovation performance. Also, the explanatory value of Model 3 is rather low (Adj-R^2 = 0.113), which indicates that the suggested model represents only a small selection of SMEs in our sample. On the basis of the hierarchical results, only H1 and H3 are accepted. Hypotheses 2, 4, 5, 6, 7, 8 and 9 are rejected.

Table 4 Moderated hierarchical regression analysis of innovation performance (N=320)

Variable	Model 1	Model 2	Model 3	VIF
Location	0.071	0.060	0.049	1.140
Age	0.026	-0.010	-0.024	1.030
Firm size	0.017	0.001	-0.020	1.100
Education	0.066	0.040	0.045	1.103

KGDS		0.028		0.225	***	1.161
KAES		0.209	***	0.195	***	1.260
RPS		0.050		0.047		1.192
LI		0.219	***	0.207	***	1.188
LI*KGDS				-0.252	***	1.191
LI*KAES				0.008		1.390
LI*RPS				-0.075		1.176
R^2	0.012	0.125		0.157		
Adj-R^2	-0.001	0.102		0.127		
F-value	0.960	5.535	***	5.217	***	
ΔR^2		0.113		0.032		
F-value for ΔR^2		10.001	***	3.948	***	

Note: *** p<0.01; ** p<0.05; * p<0.10.

6.4.2 Results: ACAP as mediator between IS and IP

Measurement and model validation

This study employs path analysis with latent variables (PALV) in SEM (undertaken with AMOS 18.0 with the Maximum Likelihood (ML) method). When using AMOS, Anderson and Gerbing (1988) recommend a two-step approach. This approach requires that, before SEM analysis is conducted, in Step 1 the latent constructs are tested to find out if they are statistically adequate for SEM analysis. This is done by means of Confirmatory Factor Analysis (CFA), whereby the latent variables are integrated into a measurement model and tested with AMOS. The results of the CFA are shown in the Appendix. Overall, the results of the CFA show that all the theoretical constructs defined by this paper are confirmed by, and fit, the sample well. Step 2 concerns the PALV, which is a type of causal modeling technique integrating path analysis and CFA, rooted in a latent model, for not only the examination of causal relationships among latent constructs but also the estimation of observed variables as well (Raykov and Marcoulides, 2001). It can be inferred that, if a PALV theoretical model is statistically specified and fitted to the associated samples, and its estimates are present at a significant level, the defined causal correlations can be said to exist in both theoretical and statistical terms. Within SEM, Jöreskog and Sörbom (1986) and Hu and Bentler (1999) suggest some cut-off criteria: The R^2 test statistic is at an insignificant level or CMIN/df < 2 if considering the complexity of the model; the Goodness of Fit Index (GFI) and adjusted GFI (AGFI) are over 0.9; the Normed Fit Index (NFI) is over 0.90; or in the case of a smaller sample size, the threshold of Comparative Fit Index (CFI) is at the 0.95 level; and, for root mean square error of approximation (RSMEA), lower is better: a benchmark of 0.05 is often used. All are met or exceeded by the model.

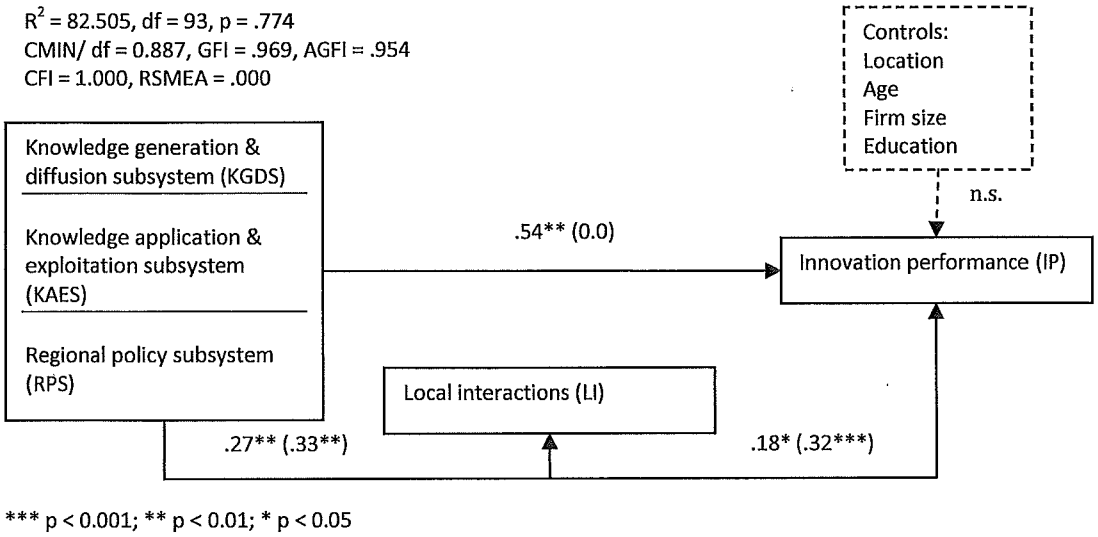

Figure 3 The (standardized) proposed model for causal relationship analyses

Hypothesis tests

The hypothesis tests for mediation compare the strength of hypotheses H10 (i.e. SMEs' innovation performance (IP) is likely to be positively influenced by absorptive capacity) with those of H10 (i.e. SMEs that use sources of innovation are likely to have increased innovation performance only through their ACAP). According to the causal relationship defined in the research framework, this study examines the mediated effects of absorptive capacity on innovation performance (see Figure 3). We first impose the constraint criterion that the path SI → IP is set to 0 (zero) (thus assuming that the possible direct effect of sources of innovation on IP should be disregarded). Overall, the model fit diagnostics of Model 1 show that the hypothetical model's statistical specification is satisfied and fits the sample well (df = 92, R^2 = 79.891 with p = 0.812). Other indices, including GFI = .969, AGFI = .954, CFI = 1.000 and RSMEA at the 0.000 level, also reach or exceed the normal benchmarks of model goodness of fit. With a sample size of n = 320, such residual covariances appear to conform to a normal distribution that is reflective of the model's statistical correctness (Jöreskog and Sörbom, 1986). Model 2 investigates the possible direct effects on innovation performance from sources of innovation (SI → IP) in order to justify the mediated role played by the absorptive capacity (ACAP) variable. Table 5 provides the chi-square difference test results for Model 1 and Model 2, where model 2 (referred to as the competing model) includes a direct path SI → IP, while Model 1 (the hypothetical model) excludes it. Overall, the two models appear to be statistically appropriate in comparing the model schemes of Model 1 and Model 2. However, the test statistics are within the rejection region of R^2 at the 0.05 significance level (ΔR^2 = 2.61, df = 1, p = 0.04),

hence indicating that there is indeed a difference in the model specification between Model 1 and Model 2. In other words, the existence of path SI → IP cannot be ignored.

Table 5 Results of model comparison (path coefficients in standardized mode).

Diagnosis and measurements	Model 1	Model 2	ΔR^2
Model fit			
R^2	62.923	44.631	18.292
Df	42	41	1
p-value	n.s. (0.020)	0.322	n.a.
Path coefficients			
SI → ACAP	0.33**	0.27**	
ACAP → IP	0.32***	0.18*	
SI → IP	n.a.	0.54**	

Note: R^2 difference test: $\Delta R^2 = 2.61$**. Model 1: excluding the path 'SI→IP'; Model 2: including the path 'SI→IP'.
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

For Hypothesis 10, we examined the possible direct effects on innovation performance (IP) from absorptive capacity (ACAP). The defined path ACAP → IP appears to be statistically significant. The standardized path coefficient of ACAP → IP in Model 2 is 0.26 ($p < 0.001$), which indicates that IP is positively influenced by the variance in IP. Hypothesis 10 is thus supported by the sample. However, Hypothesis 11 is rejected. Although the factor of SI is shown to significantly contribute positive effects to ACAP (standardized path coefficient = 0.23 with $p < 0.05$), it is evident that ACAP does not play a direct role. Model 2 has clearly identified direct and significant effects of sources of innovation on innovation performance, and that the indirect effects of sources of innovation mediated by ACAP on innovation performance are not exclusive in our sample. Therefore, Hypothesis 11 is not supported in our sample. To conduct hypothesis tests for this study, we also introduced control variables as confounders into the proposed model. This arrangement was employed to examine the possibility of an authentic relationship between innovation and firm performance according to the theoretical model. The non-significance of this latent variable shows that the introduction of those confounders does not contribute any significant obscuring or accentuating effects to the direct relationship between sources of innovation and innovation performance that we have shown to be non-existent (see Table 6). This lends further weight to the non-existence of a direct mediating role of ACAP in SMEs according to our sample's statistical behaviour.

Table 6 SEM results of the structural paths including the control variables (standardized mode).

	Model 1		Model 2	
Variables	Beta	p-value	Beta	p-value
SI → ACAP	0.229	0.013	0.229	0.015
SI - public	0.337		0.331	0.004
SI - internal	0.298	0.005	0.300	0.004
SI - horizontal	0.380	0.001	0.405	0.000
SI - educational	0.292	0.002	0.296	0.002
SI - vertical	0.619	0.000	0.598	0.000

SI - financial	0.234	0.005	0.236	0.005
SI - research	0.046	0.544	0.044	0.560
SI - informal	0.304	0.002	0.305	0.002
ACAP → IP	0.280	0.000	0.263	0.000
SI → IP	n.a.	n.a.	0.398	0.004
Radical innovation	0.444	0.000	0.434	0.000
Incremental innovation	0.574	0.000	0.617	0.000
Sales performance	0.654		0.623	
Controls → IP	0.152	0.278	0.139	0.297
Location	0.731		0.709	
Age	0.014	0.875	0.021	0.815
Firm existence	0.238	0.227	0.247	0.203
Education	0.247	0.255	0.257	0.221

Further, for a better understanding of our proposed Model 2, Table 7 provides an overview of the covariances between the error terms of the variables that were detected by the model through the modification indices and adjusted accordingly to make the model fit better. In order to lower the chi-square values, we have allowed the variables in Table 7 to be correlated. We believe there is sufficient ground to assume that these variables should be correlated, and that the analysis of the covariances can have exploratory value by further improving our understanding of knowledge interaction and collective learning of our sample. A significant positive correlation exists between informal sources of innovation and firm existence. In particular older firm may traditionally rely more heavily on informal sources like family members, for example. Also, a positive and significant correlation exists public resources of innovation and vertical ones. This correlation seems to represent the relationships of more traditional SMEs in our sample, who rely more heavily on for example the Chamber of Commerce. However, this could also point towards more innovative firms that use programmes like this for opportunity reasons. In this way, they find ways to finance their innovation with public money and thus lower financial risks. Finally, a sigificant positive correlation exists between horizontal sources of innovation and absorptive capacity. We assume that for certain SMEs in our sample, networks are formed with competitors to lower production costs. By joining networks and forming alliances particularly with larger organizations SMEs can expand their social capital (Pisano et al., 2007; Robson et al., 2011). SMEs can subsequently utilise knowledge (Yli-Renko et al., 2002) and value-creating resources that cannot be created independently.

Table 7 Covariances that were detected by SEM and adjusted in Model 2

Covariances	Beta	p-value
SI - informal ↔ Firm existence	0.122	0.039
SI - vertical ↔ Control	-0.015	0.925
SI - vertical ↔ Location	-0.129	0.422
SI - horizontal ↔ Control	0.099	0.702

SI - horizontal ↔ ACAP	0.122	0.044
SI - horizontal ↔ Firm existence	-0.102	0.206
SI- horizontal ↔ Location	0.099	0.702
SI- public↔ SI – vertical	0.147	0.018

6.5 Discussion

The results of our analyses generally support the existence of considerable knowledge spillovers from sources of innovation to firms (Audretsch and Feldman, 1996; Anselin et al., 1997; Bottazi and Peri, 2003). Although our sources of innovation do not necessarily indicate whether these spillovers are formal or informal according to the classifications of Tödtling et al. (2009), the nature of the innovation sources, i.e. whether they are horizontal or educational, give us sufficient background for interpretation. Our models suggest that market relations are important sources of innovation. According to our hierarchical regression model, in particular horizontal sources of innovation significantly and positively affect innovation performance. Further, the modification indices of our proposed causal model indicate that this effect may be particularly strong for the sales performance of an SME but less so for their innovation activities. It should be noted that the measurement of absorptive capacity (ACAP) in our models particularly highlight the positive interaction between sources of innovation and the innovation performance of larger SMEs. Internal sources of innovation, as a result, are also strongly significant and positive. We assume that they may not necessarily be representative of the innovation sources that positively affect the innovation performance of smaller firms. Further research is necessary to better understand knowledge spillover and learning in smaller SMEs.

Our study fails to find support for the existence of a moderating or mediating role of ACAP. Although our models support the findings of prior research that a sufficient degree of absorptive capacity is required for effective learning in a collaborative agreement between firms (Mowery et al., 1996; Lane et al., 2001), networking skills are probably an insufficient measure for the presence of absorptive capacity in SMEs because it appears that only a small minority of SMEs are very actively involved in such networks from our analysis. However, those firms that do make extensive use of networks appear to do so largely together with competitive firms. This is an interesting finding that deserves further study, because this may point towards specific forms of alliances that can impact an individual firm's innovation performance. This can be particularly interesting study material for SMEs lacking human capital or financial resources to identify potential partners and built networks with larger organisations. The growing realization that the network activities and resources of SMEs can be impacted by specific alliances and (larger) organizations can also be interesting information for policy makers. We thus believe that network skills can indeed be explanatory for learning behaviour of entrepreneurs and its workers, and deserves research attention. In this way, the measurement of absorptive capacity in SMEs may also be further specified.

The problem with this sample and thus analysis is the heterogeneity of its population. Although the sample is unique to the extent that it contains SMEs that are receptive for public aid, the sample seems to contain both firms that use the vouchers for opportunity reasons and SMEs that use the vouchers for necessity reasons. We have already tried to homogenize our sample by excluding the firms that did not use their voucher. However, the research may improve if we could distinguish between these groups. This would ease interpretation of our results. We assume that this is also the major flaw in the 'innovation voucher programme': although it was primarily designed for SMEs that were not familiar with knowledge transfer, it also attracted a lot of attention from more innovative firms that used the vouchers with the sole aim to lower financial risks. Future research in this direction could benefit from a strictly selected research population. Actually, this is a familiar problem that is related to the heterogeneity of the SME population in general (Westhead et al., 2011). SMEs are regarded as one entity, but there is a large variety between SMEs besides the differences in firm size. SME policy progranmmes may experience similar problems. Broad and unfocused policies to encourage all firms to survive risks are ineffective if the aim of the policy is to encourage the growth of new and small firms. Therefore, we believe that also policy can profit from a broader focus on SMEs and more specialized SME research.

6. Conclusions

6.1 Findings and implications

This study has addressed the question whether relationships exist between different information sources and the innovation performance of innovative SMEs in the Netherlands, and what the role of absorptive capacity (ACAP) is on their relationship. Our results support the assumption that, unlike larger firms, SMEs tend to rely on a broader selection of innovation sources for support in various stages of the innovation process. Therefore, a classification of knowledge interactions as suggested by (Tödtling et al., 2009) seems accurate. Our results support the strong connections of some SMEs with market relations, in particular horizontal and internal ones. Further, direct positive relations exist between SMEs and educational sources. Dynamic knowledge also influences innovation performance of SMEs in our sample, although to a lesser degree than market relations. The collective learning as suggested in the classification of Tödtling et al. (2009) is, in our sample, represented by absorptive capacity, through network intensity of the SME and contacts with an international network. There appears to be no significant moderating or mediating role of ACAP on the relationship between sources of innovation and innovation performance, although our results do show that all constructs are significant and positively related. An explanation for the insignificance of the interactions may, besides the large variety that already exists between SMEs, be

found in the design of the ACAP variable. Our measure focused on the networking skills of firms, and as such only addressed a minority of SMEs in our sample. Our study thus supports the assumption that much is still unclear about learning processes in SMEs, in particular in the smaller firms. The effect of customer alliances on innovation performance of SMEs may be an interesting starting-point for further research in this direction, but different measures mmay need to be designed for different SMEs. This paper has tried to measure alternative learning mechanisms in particulalry micro firms. Further research is necessary to find more robust ways to measure learning potential of different SMEs, and the effect of learning on innovation performance of theses firms. This will be a time consuming task, as it will require the collection of both quantitiative and qualitative data. However, as it is increasinlgy believed that SMEs are the engine of innovation in an economy, it is important to better understand the different growth phases of these firms. Therefore, we believe that research of this sort is useful and necessary for stimulation of innovation performance in a region or country.

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Appendix A

Table Results of confirmatory factor analysis

Construct and items	Standardized loading
Sources of Innovation (SI)	
SI - public	0.33
SI - vertical	0.55***
SI - internal	0.29**
SI - horizontal	0.45***
SI - financial	0.22***
SI - education	0.29***
SI - research	$0.04^{n.s}$
SI - external	0.31***
Innovation Performance (IP)	
Radical innovation	0.43
Incremental innovation	0.61***
Sales performance	0.63***
Controls	
Location	0.67
Age	$0.04^{n.s.}$
Firm existence	$0.26^{n.s.}$
Education	$0.27^{n.s.}$
CFA diagnostics	
R^2 = 67.948, df = 79, p = .808, GFI = .972, AGFI = .958, RMSEA = .000	

*** p<0.01; ** p<0.05; * p<0.10

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